

# The largest black holes and the most luminous galaxies

Hagai Netzer <sup>1</sup>

## ABSTRACT

The empirical relationship between the broad line region size and the source luminosity in active galactic nuclei (AGNs) is used to obtain black holes (BH) masses for a large number of quasars in three samples. The largest BH masses found exceed  $10^{10} M_{\odot}$  and are correlated, almost linearly, with the source luminosity. Such BH masses, when converted to galactic bulge mass and luminosity, indicate masses in excess of  $10^{13} M_{\odot}$  and  $\sigma_*$  in excess of 700 km/sec. Such massive galaxies have never been observed. The largest BHs reside, almost exclusively, in high redshift quasars. This, and the deduced BH masses, suggest that several scenarios of BH and galaxy formation are inconsistent with the observations. Either the observed size-L relationship in low luminosity AGNs does not extend to very high luminosity or else the  $M_{\text{BH}} - M_{\text{bulge}} - \sigma_*$  correlations observed in the local universe do not reflect the relations of those quantities at the epoch of galaxy formation.

*Subject headings:* black hole physics — galaxies: active — galaxies: nuclei — galaxies: high redshift — quasars: general

## 1. Introduction

Recent progress in reverberation mapping of active galactic nuclei (AGNs) allowed the first meaningful correlation between the broad line region (BLR) size ( $R_{\text{BLR}}$ ) and the black hole (BH) mass in more than 30 objects. This provided a simple way to calculate BH masses for a large number of sources and resulted in a flood of papers on this topic. Some papers (e.g. Vestergaard 2002, hereafter V02; McLure and Jarvis 2002) investigated, in great detail, the wavelength dependence of the  $R_{\text{BLR}} - L - M$  relationship and provided useful ways for adopting the method to other wavelength bands. This opens the way for the study of BH masses in large samples of high luminosity high- $z$  quasars.

---

<sup>1</sup>School of Physics and Astronomy, Raymond and Beverly Sackler Faculty of Exact Sciences, Tel-Aviv University, Tel-Aviv 69978, Israel.

All the new BH mass estimates are based on a single relationship obtained for a single sample of 34 AGNs for which BLR sizes are available from decade long reverberation mapping campaigns. More than half the sample was observed at the Wise observatory over a period of about 12 years (Kaspi et al. 2000, hereafter K00). Other objects have been monitored in other observatories and in several “AGN watch” campaigns (Netzer & Peterson 1997; Peterson 2001). The main findings are a significant  $R_{\text{BLR}} - \lambda L_{\lambda}(5100)$  relationship ( $L_{\lambda}(5100)$  is the monochromatic luminosity at 5100Å) and the confirmation that the BLR gas is in virial motion (e.g. Peterson and Wandel 2000). These, plus the (model dependent) conversion of the observed full-width at half maximum (FWHM) of various emission lines into 3-D gas velocities, are sufficient to derive the mass of the central BH.

This letter discusses the mass of the largest BH in the universe; those found in the centers of the most luminous quasars. It follows the works of Laor (1998; 2001), McLure & Jarvis (2002), Woo & Urry (2002) and others who used such methods for obtaining BH masses beyond the original K00 sample. The paper addresses also the Shields et al. (2002) new results and extends the mass estimates to much larger quasar samples. Section 2 presents new mass calculations for a large number of sources and §3 illustrates the new correlations found. Section 4 discusses the new results in light of the available information on the largest, most luminous elliptical galaxies and the epochs of quasars and galaxy formation.

## 2. The largest BH

### 2.1. BH Mass measurements

New mass estimates have been obtained for a large number of AGNs using the  $R_{\text{BLR}} - L$  relationship obtained from the K00 sample; the only sample available for such calibration. This relationship is given, schematically, by

$$R_{\text{BLR}} = c_1 L_{\lambda}^{\gamma} \quad (1)$$

which results in the following mass estimate:

$$M_{\text{BH}} = c_2 L_{\lambda}^{\gamma} [FWHM]^2 . \quad (2)$$

Here  $c_1$  and  $c_2$  are constants that include the flux normalization and various assumptions about the velocity field in the BLR. The slope  $\gamma$  is derived from the reverberation campaigns results and is in the range 0.5-0.7 (see below). The expression in eqn. 2 can be used to derived “single epoch” masses that combine the constants  $\gamma$  and  $c_2$  with observed FWHM of certain emission lines in *individual* objects. The method has been described in various papers

including K00, V02, and McLure & Jarvis (2002). Its more useful applications are based on measured  $\lambda L_\lambda(5100)$  and  $\text{FWHM}(\text{H}\beta)$  for low redshift sources (the quantities used by K00) and the combination of  $\lambda L_\lambda(1350)$  and  $\text{FWHM}(\text{C IV } \lambda 1549)$  for high redshift objects. V02 has looked into the inter-calibration of the two and supplied the expressions that are used in this work except for a small correction in the value of  $c_2$  that was introduced to adjust her constants to the cosmology assumed here:  $H_0 = 70 \text{ km s}^{-1} \text{ Mpc}^{-1}$ ,  $\Omega_m = 0.3$  and  $\Omega_\Lambda = 0.7$ . McLure & Jarvis (2002) provided similar expressions for  $MgII \lambda 2798$  which are not used in this work.

## 2.2. The sample

Three AGN samples have been used in this work: 1) the LBQS sample (Forster et al. 2000 and references therein), 2) A sample of 104 high redshift high luminosity quasars with ground-based spectrophotometry ( $L_\lambda(1350)$ ) and good  $\text{FWHM}(\text{C IV } \lambda 1549)$  measurements, and 3) the new  $L_\lambda(5100)$  and  $\text{FWHM}(\text{H}\beta)$  listed by Shields et al (2002). Many of the sources in the second sample are UM quasars and the raw data can be found in MacAlpine and Feldman 1982, Baldwin, Wampler & Gaskell (1987) and Baldwin (1977).

Forster et al. (2000) supplied monochromatic luminosities and FWHMs for many emission lines in about 1000 LBQS quasars. Since many of the sources have been observed through relatively small aperture, and under poor weather conditions, it was decided to use the Bj magnitudes that are much more accurate. This follows Green et al. (2001) who studied the Baldwin relationship in this sample and obtained monochromatic luminosities using the same method. All fluxes have been corrected for galactic reddening using the Green et al. procedure. A major assumption here, and in Green et al. (2001), is that the observed continuum can be described by a single  $L_\nu \propto \nu^{-\alpha}$  power-law with  $\alpha = 0.5$ . This approximation neglects the possible dependence of  $\alpha$  on source luminosity which may affect the  $L - M$  relationship (see §4). Forster et al. (2001) provided several different measurements of  $\text{FWHM}(\text{C IV } \lambda 1549)$  with and without the narrow line component. The “single” component fit was used and the “broad only” fit was checked to verify that the results are not sensitive to this choice. A handful of sources with  $\text{FWHM}(\text{H}\beta) < 1,000 \text{ km s}^{-1}$  or with  $\text{FWHM}(\text{C IV } \lambda 1549) > 20,000 \text{ km s}^{-1}$  were removed from the sample since those were considered unreliable or affected too much by the narrow emission line. As for the second C IV  $\lambda 1549$  sample, no galactic reddening was applied and the same assumption about  $L_\nu$  was used. In this case there is no significant dependence on  $\alpha$  since the original papers quote the observed flux at around rest wavelength of  $1450\text{\AA}$ .

The above samples are optically selected and suffer from various selection effects. This

is of no real consequence to the main goal of the paper which is to derive the mass of the largest known BHs. It may affect, however, the derived  $M - L$  correlations (§4).

### 3. The $L - M$ relationship for high luminosity AGNs

BH masses have been calculated using equation 2 and the normalizations derived by K00 and V02 adjusted to the cosmology chosen here. The determination of the slope  $\gamma$  is crucial for the present work and will be discussed prior to presentation of the new results.

We start from the original K00 sample to which we apply two statistical methods for finding  $\gamma$ : the Akritas & Bershadsky (1996) BCES estimator (for which we only consider the BCES bisector) and the *fitexy* method described in Press et al. (1992). The merits of the different methods have been discussed, extensively, in several papers and will not be repeated here. Our experience shows that the differences between the slopes obtained by the different methods are larger than the formal uncertainties on the slopes of each method. The K00 sample adjusted to the new cosmology gives  $\gamma = 0.58 \pm 0.12$  for the BCES bisector estimator and  $\gamma = 0.68 \pm 0.03$  for the *fitexy* method. The two are formally consistent with each other and  $\gamma(\text{BCES})$  was adopted here.

Since the purpose of this work is to extrapolate to very large  $L$ , we also experimented with removing the lowest luminosity objects from the sample. Removing the three objects with  $\lambda L_\lambda(5100) < 10^{43} \text{ ergs s}^{-1}$  resulted in  $\gamma(\text{BCES}) = 0.71 \pm 0.21$  and  $\gamma(\text{fitexy}) = 0.69 \pm 0.03$ . Removing the seven objects with  $\lambda L_\lambda(5100) < 10^{43.7} \text{ ergs s}^{-1}$  resulted in  $\gamma(\text{BCES}) = 0.58 \pm 0.19$  and  $\gamma(\text{fitexy}) = 0.74 \pm 0.04$ . All these results suggest that the two methods are consistent with each other and the slope cannot be determined to an accuracy better than about 0.15. The value adopted for illustrating the results of this work is the smaller one found for the entire K00,  $\gamma = 0.58$ . The implications for the case of larger or smaller  $\gamma$  are discussed in §4.

Shields et al. (2002) suggested the use of the “physically motivated” value of  $\gamma = 0.5$ . The strongest argument for using this value is the suggestion by Netzer & Laor (1993) that the outer boundary of the BLR is determined by the dust sublimation radius which is similar to the measure  $R_{\text{BLR}}$  to within a factor  $\sim 2$ . There are several problems in applying this idea to the present mass determination. First, the “reverberation radius” is determined by the responsivity of  $\text{H}\beta$  to changes in the ionizing luminosity,  $L_{\text{ion}}$ , which is smaller than the bolometric luminosity that determines the dust sublimation radius. In addition,  $\gamma = 0.5$  means the same BLR ionization parameter for low luminosity Seyferts and the highest luminosity quasars. This has never been shown to be the case in large QSO

samples. Thus, more work is required to justify this theoretical value of  $\gamma$ .

The masses computed with the  $\gamma = 0.58$  slope are presented in Fig. 1. The diagram contains data for 505 QSOs with C IV  $\lambda 1549$  measurements and 219 source with H $\beta$  measurements. The luminosity range is roughly  $\lambda L_\lambda(1350) = 10^{44-47.5}$  ergs s $^{-1}$ . Also shown is the best regression line (see below) and the mass range of  $\pm\sigma_M$  around the median calculated in luminosity bins of 0.3 dex. The largest BHs are found in sources with  $z > 2$  with  $M_{\text{BH}} \simeq 10^{10.2} M_\odot$  (15 with mass exceeding  $10^{10} M_\odot$ ). Using  $\gamma = 0.68$  (the slope found with the *fitexy* method), raise this number to about  $10^{10.4} M_\odot$  (62 with mass exceeding  $10^{10} M_\odot$ ).

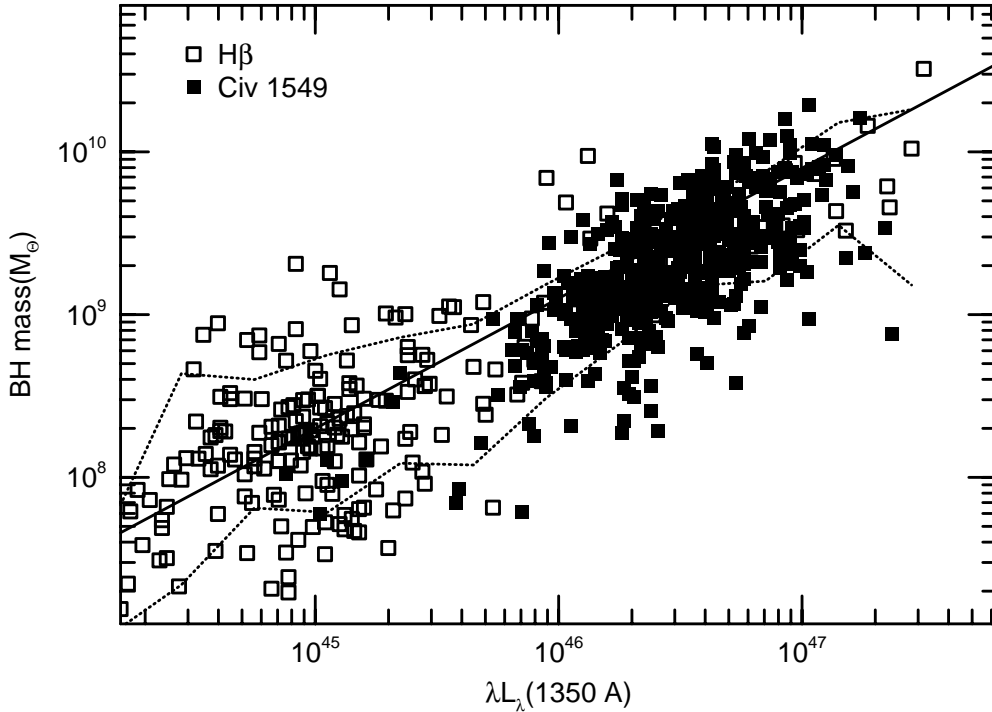


Fig. 1.— Black hole mass as a function of  $\lambda L_\lambda(1350)$  for the quasar samples described in the text assuming  $\gamma = 0.58$ . Open symbols represent mass obtained from the H $\beta$  line and full symbols masses obtained using C IV  $\lambda 1549$ . The two C IV  $\lambda 1549$  samples completely overlap in properties and were not given different symbols. The dashed lines represent the  $\pm\sigma_M$  range around the median and the straight line the  $M \propto L^{0.8}$  relationship.

Fig. 2 shows  $M_{\text{BH}}$  as a function of redshift for the same sample under the same assumptions.

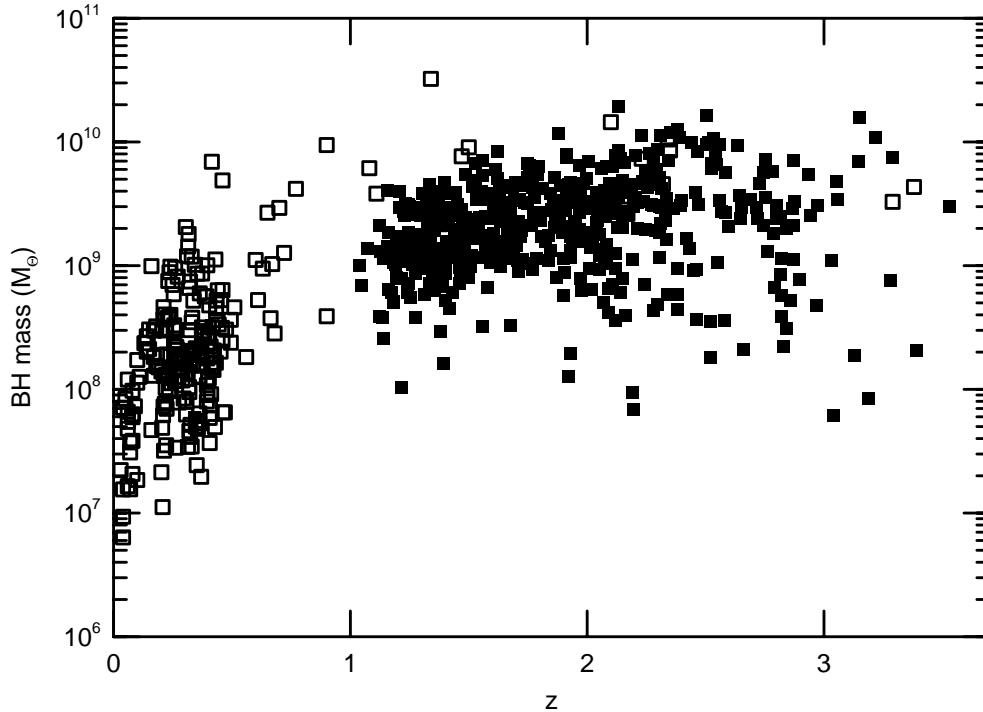


Fig. 2.—  $M_{\text{BH}}$  vs. redshift for the sample in figure 1 with the same symbols.

The data in Fig. 1 suggest a simple linear dependence of the form  $M_{\text{BH}} \propto L^\beta$ . This has been tested by performing a linear regression analysis using the same two methods described earlier. The procedure used for calculating the errors is the following: For  $L_{1350}$ , the assumption is of a constant error of 0.15 dex representing the measurement uncertainty, the extrapolation in wavelength and the typical range in luminosity due to continuum variability. This number does not affect the resulting slope  $\beta$  in any significant way. As for the mass, this was done using standard error propagation combining all errors due to the uncertainties in  $L$  and in FWHM (line width uncertainties are given in Forster et al. 2000). The combined error for this case is typically 0.15-0.25 dex. No uncertainties are listed for FWHM(C IV  $\lambda 1549$ ) in the second quasar sample and for FWHM(H $\beta$ ) in Shields et al. (2002). A uniform error of 0.2 dex in  $M_{\text{BH}}$  was assumed in those cases. The errors are relatively large and are expressed

in logarithmic form (i.e.  $0.5(\log(x+dx)-\log(x-dx))$ , see Lyons, 1991).

Table 1 lists several slopes obtained by the two methods for our standard case of  $\gamma = 0.58$  and for  $\gamma = 0.68$ , the slope obtained by the *fitexy* method. Given the various biases and unknowns, it is reasonable to assume that the real uncertainty in  $\beta$  is at least as large as  $\pm 0.15$ . With this uncertainty, the slopes of the C IV  $\lambda 1549$  sample and the entire sample are barely consistent with each other and the slopes of the H $\beta$  sample and the entire sample are indistinguishable. The scatter in slope is probably due to the very different luminosity range of the C IV  $\lambda 1549$  and the H $\beta$  samples. A second approach that was tried assumed a uniform uncertainty in  $M_{\text{BH}}$  of 0.3 dex for all objects. This gave very similar results. The overall conclusion is that for luminous AGNs,  $M_{\text{BH}} \propto L^{0.9 \pm 0.15}$ .

The  $M_{\text{BH}} - L$  correlation found here is very different from the one found in K00. The reason is probably the incompleteness of the small K00 sample which resulted in a biased sampling of  $\text{FWHM}(\text{H}\beta)$  vs.  $\lambda L_{\lambda}(5100)$  not representing the parent population. Indeed, K00 found  $\text{FWHM}(\text{H}\beta) \propto L^{-0.27}$  while in the samples under study the correlation is much flatter. The FWHM–luminosity dependence in various samples will be addressed in a separate paper (Corbett et al. 2003).

The tight  $M_{\text{BH}} - L$  relationship enables the study of the Eddington ratio,  $L/L_{\text{Edd}}$ , in these samples. The observed  $M - L$  relationship suggests a very weak, if any dependence of  $L/L_{\text{Edd}}$  on  $L$  or on  $M_{\text{BH}}$ . This impression is confirmed by a formal statistical analysis. Since the results are marginal, they will not be presented here. Another important issue is the mean  $L/L_{\text{Edd}}$ . This depends on the distribution in this property as well as on the exact conversion from  $\lambda L_{\lambda}$  to bolometric luminosity and the value of  $\gamma$ . Assuming first  $\gamma = 0.58$  and  $L_{\text{Edd}} = 9\lambda L_{\lambda}(5100)$ , as in K00, gives a median  $L/L_{\text{Edd}}$  of 0.53. The composite spectra published recently by Telfer et al. (2002) suggest a different conversion with  $L_{\text{Edd}} \simeq 5\lambda L_{\lambda}(5100)$ . This translates to a median of 0.28. The above values are transformed to 0.33 and 0.18 for the case of  $\gamma = 0.68$ . In both cases the distribution was wide, covering about a factor 10 in  $L_{\text{Edd}}$ . Thus, the choice of  $\gamma = 0.58$  results in a large mean  $L/L_{\text{Edd}}$  and a large number of sources with super Eddington luminosities. As explained by Woo and Urry (2002), the implications to the derived  $M_{\text{BH}} - L$  relation are very important (see §4).

#### 4. Discussion: the largest BHs and the most luminous galaxies

The new results presented here suggest that the largest BHs are situated in the most luminous quasars that are, typically, the highest redshift sources. At the extreme end of the distribution we find BH masses of order  $5 \times 10^{10} M_{\odot}$  if  $\gamma = 0.7$ , and  $1.1 \times 10^{10} M_{\odot}$  if  $\gamma = 0.5$ .

This is greater than obtained so far in large samples. The recent work by Shields et al. (2002) aimed at the calibration of the the [O III]  $\lambda 5007$  line width as a bulge mass estimator. The method is based on the close agreement between FWHM([O III]  $\lambda 5007$ ) and the stellar velocity dispersion  $\sigma_*$  at low luminosity and the K00 mass estimates at higher luminosity. Using this method and  $\gamma = 0.5$  (their Table 2) they find one object with  $M_{\text{BH}}$  exceeding  $10^{10} M_{\odot}$  and several others approaching this mass. As shown in Fig. 1, the C IV  $\lambda 1549$  samples includes many more sources with such large masses.

Before addressing the cosmological consequences we note the various factors influencing the  $M - L$  relationship and likely reasons for overestimating  $M_{\text{BH}}$ .

1. The K00 sample covers a limited luminosity range and all mass estimates corresponding to  $\lambda L_{\lambda}(1350) > 10^{46}$  are necessarily obtained by extrapolation. Since this is *the only* sample available so far, there is no independent way to verify the largest masses until successful reverberation mappings are obtained for higher luminosity AGN. Moreover, as explained in §2, the slope of the  $R_{\text{BLR}}-L$  relationship is uncertain. The slope chosen here ( $\gamma = 0.58$ ) is close to the middle of the range. Its increase to 0.7 will increase the mass at the high luminosity end by a factor of about 2.5.
2. The largest new mass estimates are based on the measured  $\lambda L_{\lambda}(1350)$  which is scaled to the K00 luminosity assuming the same spectral energy distribution (SED) for high and low luminosity AGNs. This assumption has never been tested in large quasar samples. The data for such test are already available (Telfer et al. 2002) but the results are not yet known. Intrinsic reddening, in the quasar host galaxy, is another potential complication related to the inter-calibration of optical and UV luminosities.
3. The FWHM(C IV  $\lambda 1549$ ) may not reflect the virial motion of the BLR gas in high luminosity quasars.
4. The samples used here suffer from various selection effects. This influence only slightly the largest derived masses but can affect much more the  $L - M_{\text{BH}}$  correlation. For example, magnitude limited samples may not include the less luminous quasars, those with the smallest  $L/L_{\text{Edd}}$ . This results in a false impression of a very strong  $M - L$  correlation. Woo and Urry (2002) investigated this idea in great detail and concluded that all strong  $M - L$  correlations obtained so far suffer from such a selection effect.

The main conclusion of this work is that the largest BH masses are found in the highest luminosity quasars. The masses of such BHs can reach the extreme values of  $10^{10.3-10.6} M_{\odot}$ , depending on the value of  $\gamma$ . Using recent conversions to host galaxy properties one finds



$M_{\text{bulge}} \sim 10^{13.1-13.4} M_{\odot}$  (Kormendy & Gebhardt 2001),  $M_{\text{B,bulge}} \sim -25$  mag (Kormendy 2001) and  $\sigma_*$  exceeding 800 km/sec (Tremaine et al. 2002). Such galaxies have never been observed and are not predicted to exist by standard galaxy formation theories.

In principle, this is still consistent with the observations since the sources with the largest  $M_{\text{BH}}$  are the most luminous ones and will completely out-shine any host galaxy. Thus, there is no direct way to rule out the existence of such galaxies. However, the theoretical implication are in conflict with recent ideas that the largest galaxies attain their mass through a series of mergers, a process that operates continuously to redshift 2 or smaller. A similar difficulty is found for the BH growth since those same theories (e.g. Haehnelt and Kauffman 2000; Yu and Tremaine 2002) assume that galactic nuclei BHs increase their mass up to redshifts smaller than 2 by the same series of mergers (or, perhaps, only through large mergers). Thus, the largest BHs are predicted to be associated with the most massive galaxies at  $z < 2$ , in conflict with the data in Fig. 2. It is clear that active BH with  $M_{\text{BH}} > 10^{10} M_{\odot}$  are not found in the local universe. It is also clear that dormant BHs of this mass, or the galaxies with extreme properties that are supposed to host such BHs, have never been found. The whereabouts of the huge BH formed at  $z \simeq 3$  is thus unknown.

A more plausible suggestion is that some or all the conversion factors used to obtain the galactic mass, magnitude and  $\sigma_*$  from the BH mass, that are based on measurements in the local universe, cannot be extrapolated to high luminosity high redshift objects. Perhaps they are only valid at  $z < 2$ , after galaxies and nuclear BHs have accumulated most of their mass. If correct, this would mean that some “normal looking” galaxies contain extremely massive BHs. A similar suggestion by Laor (2001) involves a dependence of  $M_{\text{BH}}/M_{\text{bulge}}$  on the BH mass or the absolute magnitude of the host galaxy.

To conclude, either the measurements of BH masses presented here for the most luminous quasars are grossly overestimated, because of the reasons described above, or else the relationships between BH masses and various properties of their host galaxies at high  $z$  are very different from those measured in the local universe. A second conclusion, which is less certain because of various selection effects, is that for AGNs,  $M_{\text{BH}} \propto L^{0.9 \pm 0.15}$ .

The work described in this paper is based primarily on a decade-long AGN monitoring project at the Wise observatory. I am grateful to many of my colleagues and students that helped in making this into a very successful project. Special thanks go to Dan Maoz, Shai Kaspi and Ohad Shemmer who led various parts of the project and without whom it would have been impossible to bring it to completion. Useful discussions with Ari Laor are gratefully acknowledged. This work is supported by the Israel Science Foundation grant 545/00.

## REFERENCES

- [25]
- [25] Baldwin, J.A., 1977, ApJ 214, 679
- [25] Baldwin, J.A., Wampler, E.J., & Gaskell, C.M., 1987, ApJ 338, 630 Ferrarese, L., Pogge, R.E., Peterson, B.M., Merritt, D., Wandel, A., & Joseph, C.L., 2001, ApJ 555, L79
- [25] Forster, K., Green, P.J., Aldcroft, T.L., Vestergaard, M., Foltz, C.B., & Hewett, P.C., 2001, ApJS 134, 35
- [25] Green, P.J., Forster, K., & Kuraszkiewicz, J., 2001, ApJ 556, 727
- [25] Haehnelt, M., & Kauffman, G., 2000, MNRAS 318, l35
- [25] Kaspi, S., Smith, P.S., Netzer, H., Maoz, D., Jannuzi, B.T., & Giveon, U., 2000, ApJ 533, 631 (K00)
- [25] Kormendy, J., & Gebhardt, K, 2001, in The 20th Texas Symposium on Relativistic Astrophysics, ed. H. Martel & J.C. Wheeler (AIP) , 363
- [25] Kormendy, J., 2001, *RevMexAA* conference series, 10, 69
- [25] Laor, A., 1998, ApJ 505, L83
- [25] Laor, A., 2001, ApJ 553, L677
- [25] Lyons, L., *A Practical Guide to Data Analysis for Physical Science Students*, 1991, Cambridge University Press
- [25] MacAlpine, G., & Feldman, 1982, ApJ 261, 412
- [25] Maoz, D., 2002 (astro-ph/0207295)
- [25] McLure, R.J., & Jarvis, M.J., 2002 (MNRAS in press, astro-ph0204473)
- [25] Netzer, H., & Laor, A., 1993, ApJ 404, L51
- [25] Netzer, H., & Peterson, B.M., 1997, in *Astronomical Time Series*, Kluwer, (Maoz, Sternberg & Leibowitz eds.)
- [25] Peterson, B.M., 2001, in *The Starburst-AGN connection*, World Scientific (I. Aretxaga, D. Kunth & R. Mujica eds)

- [25] Peterson, M.M., & Wandel, A., 2000 ApJ 540, L13
- [25] Peterson, B.M., et al. 2000, ApJ 542, 161
- [25] Shields, G.A., Gebhardt, K., Salviander, S., Wills, B.J., Bingrong, X., Brotherton, M.S., Yuan, J., & Dietrich, M., ApJ (in press astro-ph/0210050)
- [25] Telfer, R.C., Zheng, W., Kriss, G.A., & Davidsen, A.F., 2002, ApJ 565, 773
- [25] Tremaine, S., et al., 2002, ApJ 547, 740
- [25] Yu, Q., & Tremaine, S., 2002, MNRAS 335, 965 Vestergaard, M, 2002, ApJ 571, 733 (V02)
- [25] Woo, J.H., & Urry, C.M., 2002 (ApJ, in press; astro-ph/0207249)

Table 1. Regression analysis results for  $M_{\text{BH}} = aL_{1350}^{\beta}$

method	$\gamma$	sample	$\beta$	$a$
BCES Bisector	0.58	all C iv $\lambda 1549$	$1.12 \pm 0.05$	-42.9
<i>fitexy</i>	0.58	all C iv $\lambda 1549$	$1.13 \pm 0.04$	-43.1
BCES Bisector	0.58	all H $\beta$	$0.83 \pm 0.03$	-29.2
<i>fitexy</i>	0.58	all H $\beta$	$0.80 \pm 0.02$	-27.6
BCES Bisector	0.58	all objects	$0.80 \pm 0.02$	-27.7
<i>fitexy</i>	0.58	all objects	$0.78 \pm 0.01$	-26.9
BCES Bisector	0.68	all objects	$0.90 \pm 0.02$	-32.2
<i>fitexy</i>	0.68	all objects	$0.89 \pm 0.01$	-31.9